Astrometrical Observations of the Near-Earth Asteroid 308635 (2005 YU55) in Nikolaev

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Introduction

A near-Earth asteroid 308635 (2005 YU55) was discovered by Spacewatch group at Kitt Peak Observatory (691) on December 28, 2005. The asteroid belongs to the Apollo group, moreover it is a potentially hazardous asteroid presented in the critical list of the Minor Planet Center, the minimum orbit intersection distance of the asteroid with the Earth is 0.000454 a.u. As to the radar observations in 2010, the diameter of the asteroid is 0.4 km. Due to the high eccentricity of its orbit, the asteroid has close encounters not only with the Earth and the Moon, but also with Venus and Mars, so the orbit of this asteroid can be a subject of special interest for studying different gravitational perturbations.

During the period of close encounter with the Earth, the visible angular speed of near-Earth asteroids increases greatly, so such asteroids may cause difficulties for observations by classical methods. Nevertheless these observations allow to reveal and estimate possible errors in observation. The aim of the article is to discuss results of astrometric observations in Nikolaev Observatory of the asteroid 308635 (2005 YU55) during its close encounter with the Earth in November 2011.

1. Instrumentation, observations and reduction

There were two close approaches with this asteroid in 2011. The first one took place at 0.00217 a.u. with the Earth on November 8.98, the second one took place at 0.00160 a.u. with the Moon on November 9.30, 7.7 hours later. The maximum brightness of the asteroid was 11.2 mag, the maximum visible speed achieved 8.6 degrees per hour. The solar elongation was 84º, and increased with time, so the conditions of observations allowed to observe the asteroid even with small telescopes and the Moon visible all the night within the dates of close encounters.

The asteroid was observed with the telescope Mobitel of Maksutov system (D=0.5 m, F=3.0 m) by two different groups in Nikolaev Observatory (089) on three nights November 9, 17, 18; however we shall study solely the results obtained in the first two nights by the author of the present article. The telescope is equipped with the CCD camera Alta U9000 (3056 x 3056, 12 x 12 mkm^2) of Apogee Imaging Systems. The peculiarity of the telescope consists in using solely time delay and integration mode for observations which allows to get imaging strips 42' in width and scale 0.82″/pixel. The observations were made in R Johnson-Cousins-Bessel band. The field of view allows to get number of reference stars enough for reduction in the UCAC catalogs.

The greatest difficulty in observing the asteroid was its great speed on November 9 in comparison to the one on November 17. The mean components of asteroid velocities calculated for the observed times using the HORIZONS service of JPL [1] (http://ssd.jpl.nasa.gov/?horizons) as well as visual magnitudes are given in Tabl. 1. The length of exposure was adjusted to the ephemeride speed of the asteroid as to get images stretched due to its relative visible speed for no more than two full width at half maximum; the later one was estimated in 2.6″. This idea allowed to get slightly stretched images of the asteroid and to simplify further measurements by using the circular Gaussian function for profile fitting. It is easily seen in Tabl. 1 and can be demonstrated on the motion of Ceres (1) on the same dates, that the visible speed of the near-Earth asteroid on November 17 was comparable to the one of the main belt asteroids, so these observations on this date give estimations of astrometric precision which can be reached using current imaging and classical methods of reduction.

Table 1: Mean visible velocities and brightnesses of the asteroid during the observations

Evening dates	$v_\alpha \cos\delta$, arcsec/min	v_δ, arcsec/min	Visual brightness, mag.
09/11/11	39.67	–4.17	12.0
17/11/11	0.24	–0.12	16.6

So, the astrometric results are represented by 160 positions, which were obtained in two different nights on November 9 and 17 [2]. The differential reduction was made with the UCAC2 catalogue using full second order polynomials. We have found them appropriate for elimination of the possible errors produced by inaccuracy in position caused by small arbitrariness in choosing the projection center for the given field of view.

2. Analysis of observations

For analysis purposes, there were calculated differences between observed (O) and calculated (C) positions which are plotted on the Fig. 1. The calculated positions represent ephemeride positions of the asteroid found using the HORIZONS service of JPL. The orbit of the asteroid used by HORIZONS has been fitted to 2555 observations except for the discussed ones. The overall precision of the orbit is represented with RMS of residuals equal to 0.36".

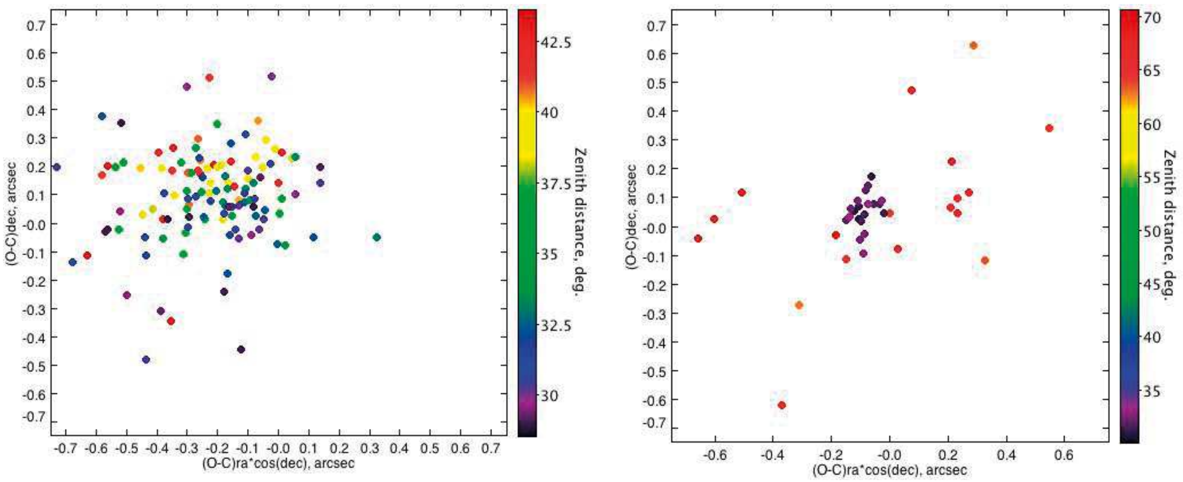

Fig. 1. Distribution of (O–C) in positions for two dates of observations: the left figure corresponds to observations made on November 9, the right one to November 17.

As one can find from Fig. 1, the series of Nikolaev observations made on November 9 has the same mean value and dispersion, while it is easily revealed two series of observations made on November 17. Simple hypothesis testing on the homogeneity of the residuals suggests only a significant difference in dispersion between two series of observations on November 17. The summary basic statistics of the residuals is presented in Tab. 2, where there are given mean values of the residuals and RMS errors for a single position of the asteroid. Besides, one can find that the precision of a single observation depends on zenith distance of the asteroid.

Considering the change in speed of the asteroid in November 2011, Tabl. 1, the corresponding astrometric precision obtained, Tabl. 2, and also zenith distances of the observations (Fig. 1), one can make a conclusion that the precision of astrometric measurements using classical reduction for a star-like object can be as smaller as 0.07″ that corresponds to 0.08 pixel in the focal plane, while the significant motion increases it to 0.25″ or 3 times.The increase of zenith distance of the observations deteriorated considerably the precision to 0.43″ on November 17.

Table 2: Basic statistics of the astrometric results

Evening dates	Numbers of positions	$(O–C)_\alpha \cos\delta$, arcsec	$\sigma_\alpha \cos\delta$, arcsec	$(O–C)_\delta$, arcsec	σ_δ, arcsec
09/11/11	122	–0.22	0.19	+0.09	0.16
17/11/11 (1)	20	–0.09	0.03	+0.05	0.06
17/11/11 (2)	18	–0.02	0.34	+0.05	0.27
Total/ Weighted	160		0.20		0.17

Conclusion

For two nights on November 9 and 17, there were obtained 160 positions at the Mobitel telescope in Nikolaev Observatory during the apparition of the near-Earth asteroid 308635 (2005 YU55) in the end of 2011. The best achieved precision in astrometric measurements for a slowly moving object was estimated 0.07″, while for fast moving object it was 0.25″. These results support the adopted technique of observations of the fast moving objects.

As far as the weighted RMS error 0.26″ of the discussed astrometric positions of the asteroid obtained in Nikolaev on November 9 and 17 is less than RMS error 0.36" of the orbit used, and considering numbers of observations used for calculation both of them, we expect 2% decreasing of the RMS error orbit fit after subsequent improvement.

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